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Managing Water in the West

Climate Change and Reservoir Operations in the West

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Climate Change and Water Resources, Joint HQ Meeting
31 May 2007, USACE Institute for Water Resources, Washington, D.C.

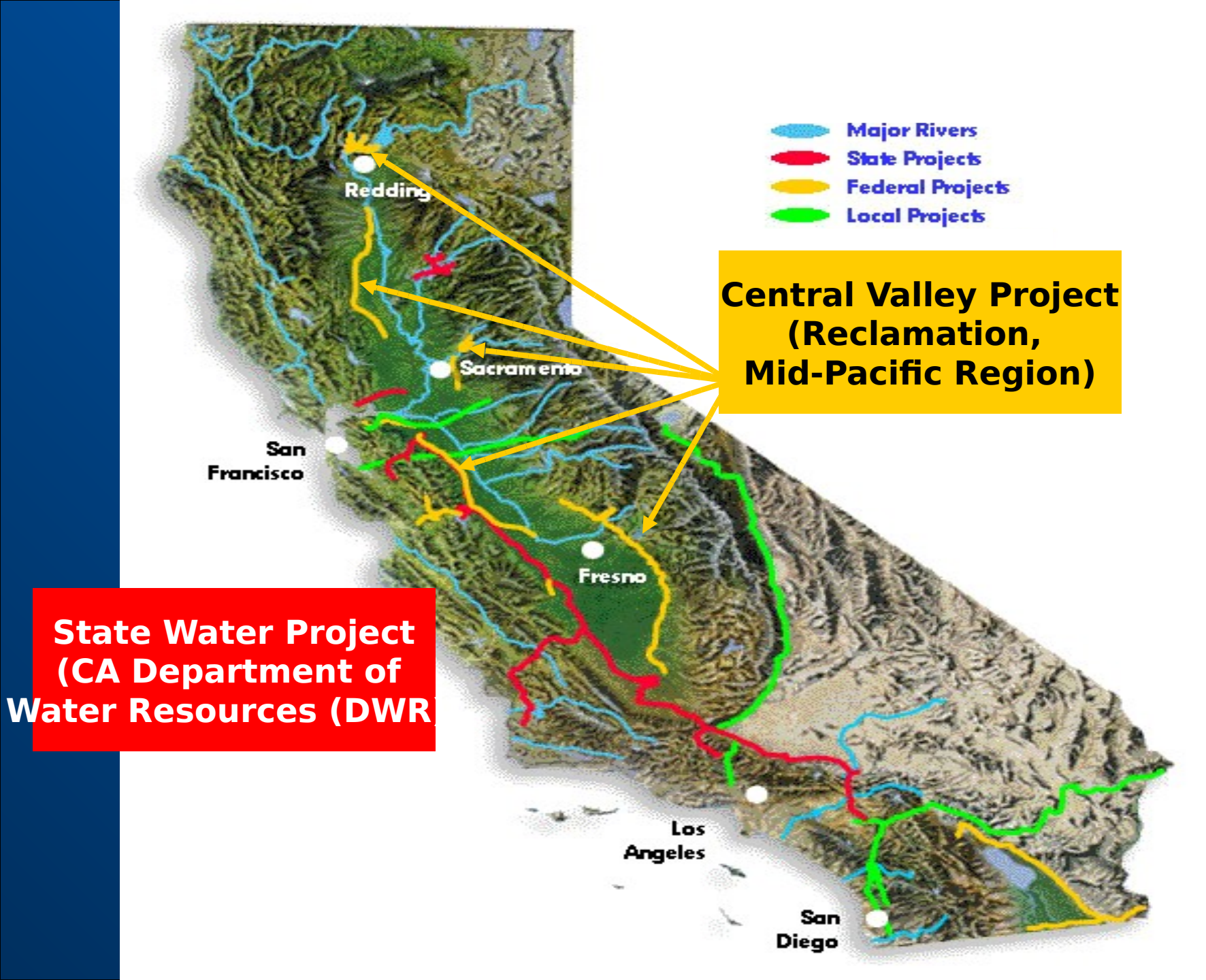
U.S. Department of the Interior
Bureau of Reclamation

Research on Use of Climate Change Information in Long-Term Evaluations

- Several ongoing evaluations
  - LC, MP, PN regions

- Focus here on two efforts:
  1. CVP/SWP Climate Change Risk Study
  2. Archive Development, Downscaled IPCC AR4 Climate Projections

The findings and conclusions of these efforts have not been formally disseminated by Reclamation and should not be construed to represent any agency determination or policy.


Major Rivers
State Projects
Federal Projects
Local Projects
Redding
Sacramento
San Francisco
Fresno
Los Angeles
San Diego
Central Valley Project (Reclamation, Mid-Pacific Region)
State Water Project (CA Department of Water Resources (DWR)

CVP/SWP Climate Change Risk Study (FY2006-2007)

- Purpose
  - Move discussion beyond “potential impacts”
  - Use risk analysis principles
    - Risk Assessment based on
      1. Projections Uncertainty (relative scenario probabilities)
      2. Scenario-Specific Impacts Assessment
    - Risk Management based on Risk, Values, Options…
  - Produce methods for use in Reclamation regions
  - Produce information for MP Region CVP Planners
- Collaborators
  - Reclamation, CA-DWR, M. Dettinger (USGS), E. Maurer (Santa Clara University), USACE

Projection Uncertainty Analysis

- Surveyed 75 IPCC AR4 projections of either SRES A2 or B1, collectively from 17 climate models

- Considered future and base 30-year climate norms & fit distributions to change in norms
  - Temperature (T), Precipitation (P), and joint {T, P}
  - with and without considering climate model skill
    - Philosophy: skill in simulating the past indicates credibility in projecting the future
    - Based on 59 “historical” (20c3m) simulations from the models

- Using distributions to estimate relative probabilities for *impacts-assessment scenarios*

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Impacts analyzed for 22 Scenarios (Maurer 2007; DWR 2006)

(Maurer 2007):

IPCC AR4 projections of SRES A2 and B1 from 11 coupled atmosphere-ocean climate models that participated in the 20th Century Climate

Each projection was:

-- bias-corrected & spatially downscaled (Wood et al. 2004)

-- sampled 1963-92, 2011-40, 2041-70 for mean monthly

Surface Water Hydrology

Headwater Runoff

Social Water Demands*

Complete

System Operations

Water Deliveries,

Reservoir Storage

Complete

Dependent Effects

Hydropower;

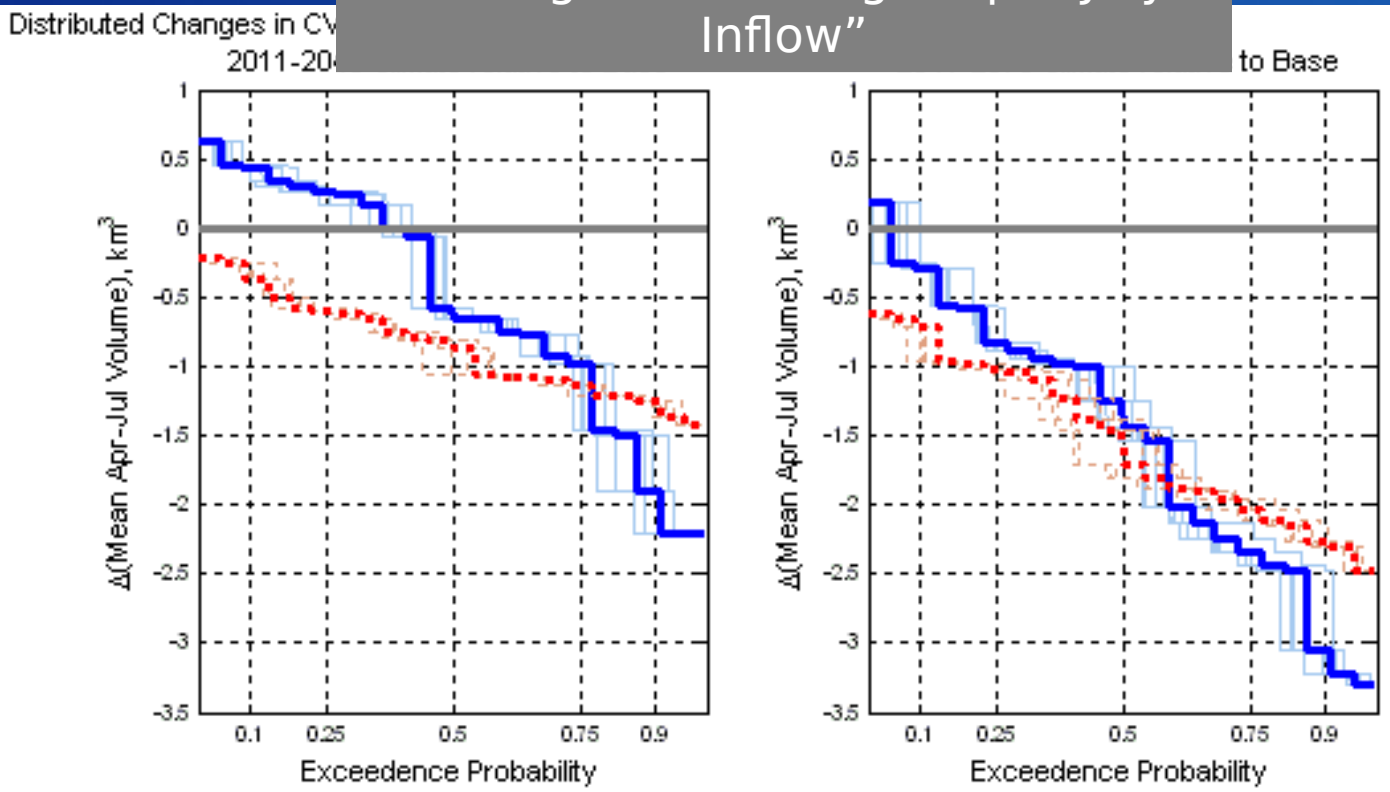
Stream Temperatures,

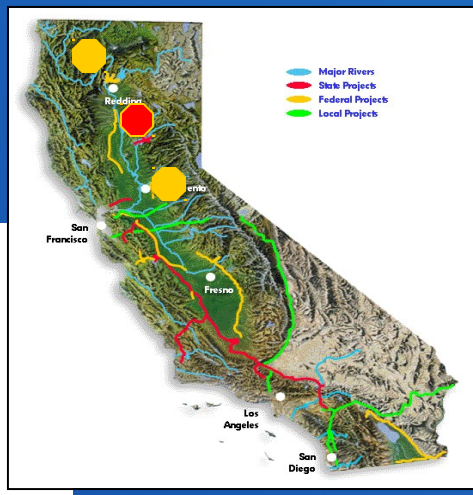
Delta Salinity & Water Levels

Current Work

Example Runoff Risk: April-July Inflow, CVP+SWP North

Impact, distributed across 22 scenarios, to Long-Term Average "April-July Inflow"





---- **T & P change**

---- **T change only**

Thick lines: equal scenario probabilities.

Thin lines: reflect unequal scenario probabilities

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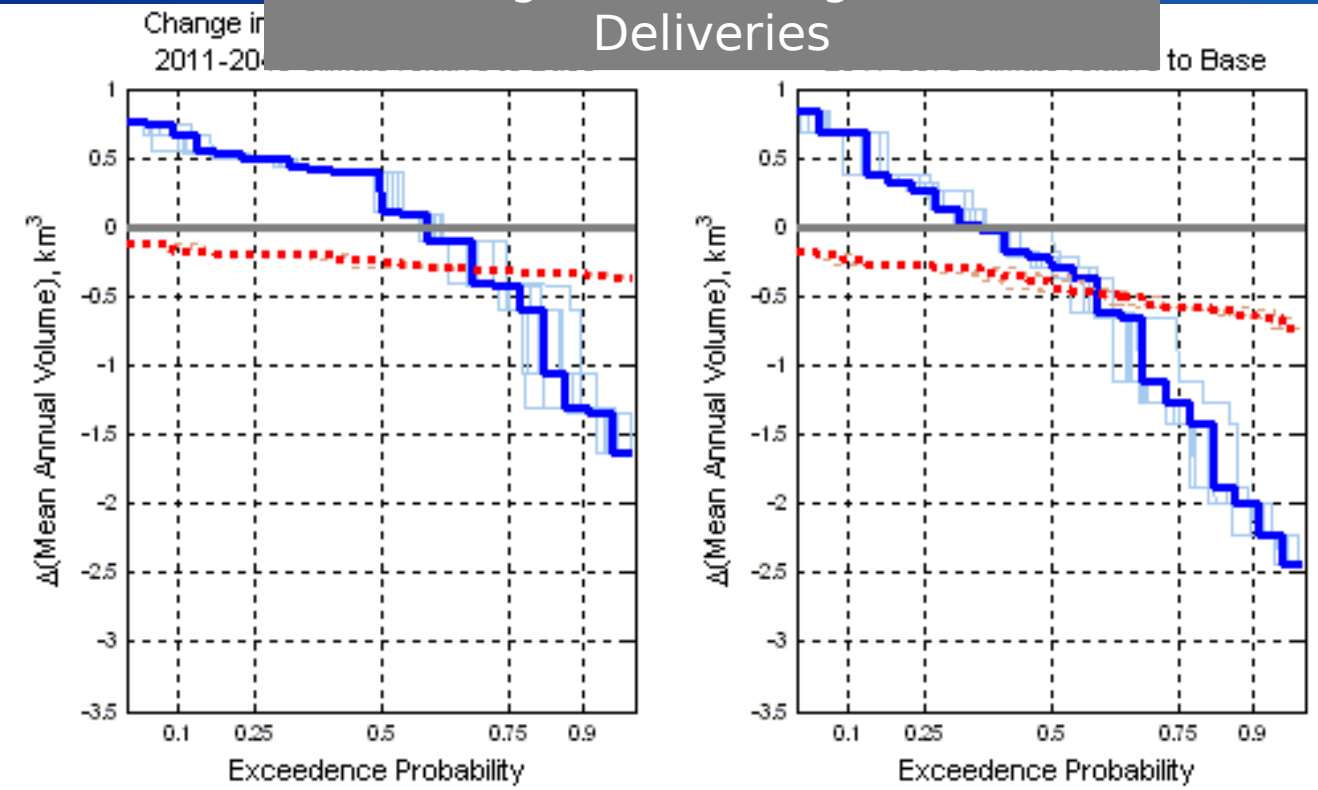
Example Operations Risk: Annual CVP+SWP Deliveries

Impact, distributed across 22 scenarios, to Long-Term Average Annual Deliveries



---- **T & P change**

---- **T change only**

Thick lines: equal scenario probabilities.

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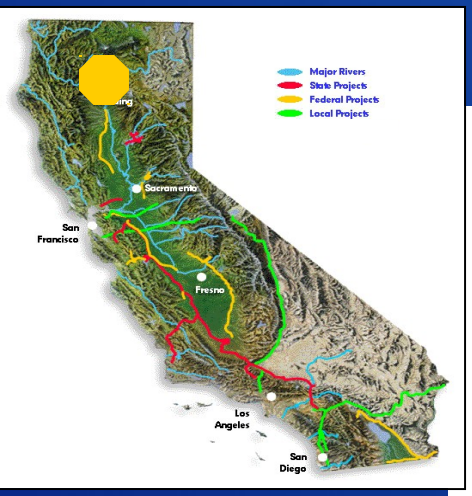
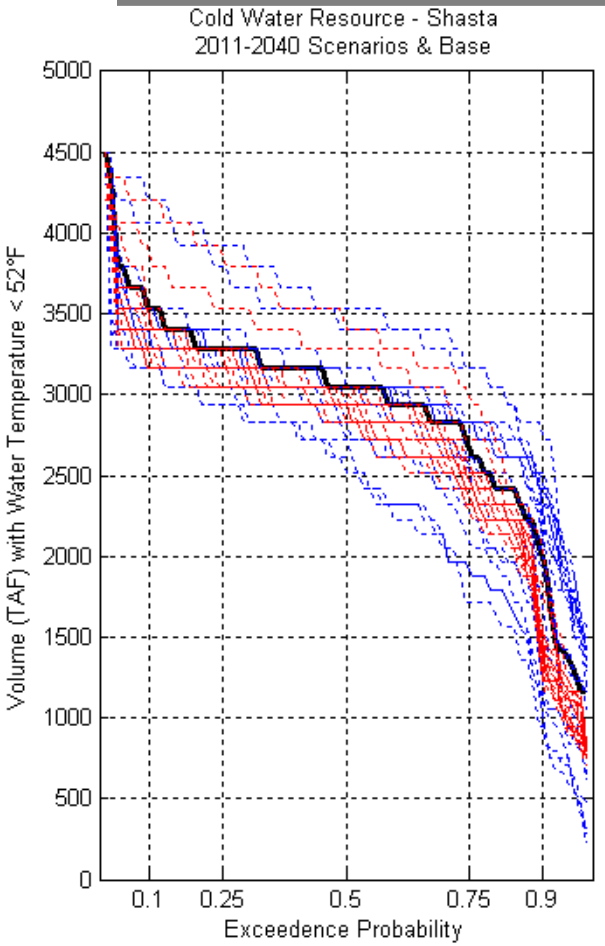
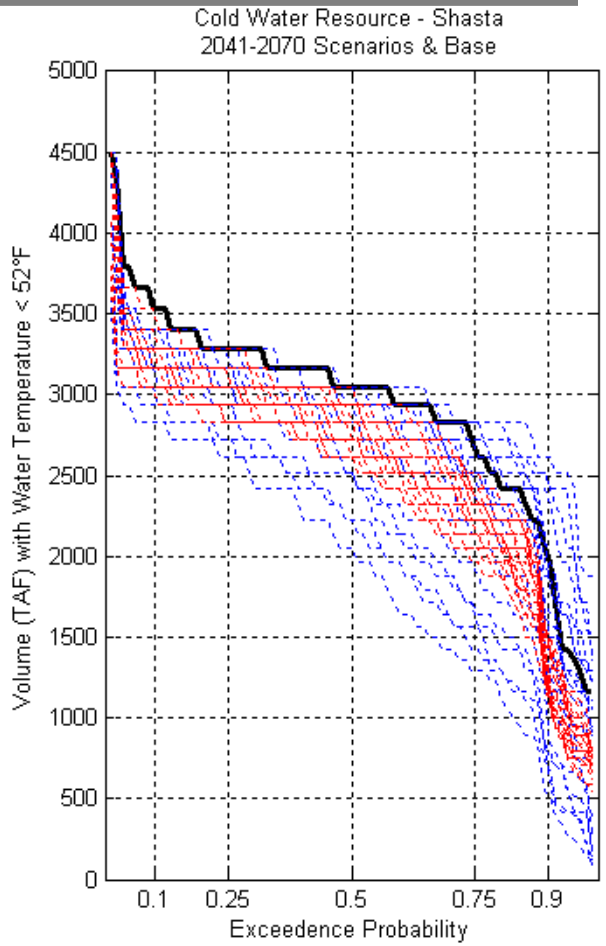
Environmental Risk: Lake Shasta Cold Water "Pool"



Scenario-specific distributions of Shasta cold pool across simulation years





22 Scenarios, T & P change

22 Scenarios, T change only

Base

Future Flood Control?

- Results shown are based on current rules
- Will we require deeper winter drafting?
  - *Revisited 3 scenarios, two futures, two rules:*
    - *Current*
    - *Modified: 10% more Nov-Mar flood space volume*
  - Effect on CVP South Deliveries: ~doubled impact
- *Was Modified rule a reasonable assumption?*

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Analyzed 3-day, 30-year-max volume runoff response to "warming" of historical storms:

Median of 22 Scenarios' %-change, period to period

Basin	2011-40 vs 1963-92	2041-70 vs 1963-92
Shasta, Sacto	2	4
Feather, M.F.	22	33
Yuba, N.B.B.	12	15
Tuolumne, H.H.	13	28
Merced, P.B.	8	18

Numbers are approximate; estimated from graphical

(Sacramento) Interagency Workshops, Flood Control & Climate Change

- Context
  - Two Workshops: 3/29/07, 5/24/07
  - Motivated by CVP/SWP Climate Change Risk Study,
  - Obtain flood operators' guidance on flood control assumptions

- Messages heard
  - Re: Monthly Scheduling, Flood Control Rule Revisions
    - More adaptive flood control procedures desired
  - Re: Long-Term Project Evaluations (Water Supply)
    - Recognition that deeper winter drafting seems possible
    - Recognition that forecasting draft change is difficult, requires understanding of future types of storms and future societal values on flood protection… cannot quantify either at this time.

Project Status & Preliminary Summary

- Runoff
  - Median impact → reduced Spring inflow volume
- Operations
  - Median impact → reduced deliveries, reduced storage
  - Flood control assumptions strongly influence risk
- Environment
  - By mid-21st Century: near certain *cold water pool* reduction
- On Use of Projections
  - degree of climate model weighting had little influence on risk
  - Including/excluding P projections is a key consideration
- Next Steps:
  - Focus on risk management to address cold water pool risks
  - Journal Articles (1 submitted, 2 others in development)

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Archive Development, Downscaled IPCC AR4 Climate Projections

- Purpose
  - Support Reclamation's long-term project evaluations
  - Need climate projections at basin-relevant resolution

- Approach
  - Build archive of bias-corrected and spatially downscaled IPCC AR4 projections on a monthly time-step at 1/8 degree resolution (Wood et al. 2004)
  - Complete by end-of-FY2007
  - Work with LLNL (Phil Duffy, Jeff Stewart) and SCU (Ed Maurer)
    - LLNL to host archive
    - Maurer to provide algorithms
    - Reclamation to apply algorithms & populate archive

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Extras

Climate Model Weighting: Variables & Metrics

Statistic, Metric, or Correlation	Variable, monthly, 1950-1999 Global, Local, or Teleconnections			
	NorCalT	NorCalP	NPI	Nino3
Long-Term Mean				
Long-Term Var.				
Long-Term Var, Interdec.				
Long-Term Skewness				
Mo. Means: Seas. Amp.				
Mo. Means: Seas. Phase				
6yr sum, 90% exc.				
Annual Max Mo. 10% exc.				
El Nino Reoccurrence				
Seasonal Corr with NPI	(4)	(4)		
Seasonal Corr with Nino3	(4)	(4)	(4)	
Annual Corr with Nino3				

Climate Model Weighting: Sensitivity to measured Variables